REPORT OF THE

Tropical Products Institute

1960

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Cover illustration: Nigerian woman preparing gari on village scale

DEPARTMENT OF
SCIENTIFIC AND INDUSTRIAL RESEARCH

REPORT OF THE TROPICAL PRODUCTS INSTITUTE 1960

The Report of the
Tropical Products Institute Committee
with the Report of the
Director of the Tropical Products Institute

LONDON
HER MAJESTY'S STATIONERY OFFICE
1961

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[1]Sir Eric Ashby retired from the Committee during the year.
[2]Mr. G. W. St. J. Chadwick took Mr. G. E. B. Shannon's place on the Committee during the year.
[3]Mr. E. S. Hiscocks replaced Dr. R. A. E. Galley as Director of the Tropical Products Institute during the year.

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REPORT OF THE TROPICAL PRODUCTS INSTITUTE COMMITTEE FOR 1960

To the Council for Scientific and Industrial Research

We, the Tropical Products Institute Committee, beg leave to present a report of our proceedings for the period 1st January to 31st December 1960.

During the course of the year one of our members, Sir Eric Ashby, retired from the Research Council and from the Committee, and as a result of reorganization within the Commonwealth Relations Office we welcomed Mr. G. W. St. J. Chadwick in place of Mr. G. B. Shannon.

Dr. R. A. E. Galley, who had been Director of the Institute since 1953, resigned in June 1960 to take up an appointment in industry. From June to November Dr. P. C. Spensley was Acting Director and in November we welcomed Mr. E. S. Hiscocks, formerly Director of the U.K. Scientific Mission in Washington, as the new Director of the Institute. We would like to place on record our appreciation of Dr. Galley's services to the Institute during his period of office as Director, and particularly during the period since we were appointed, and to express our good wishes for his future career.

We are pleased to report that the expansion in staff referred to in our previous report is virtually complete, and during the forthcoming year the Institute will for the first time be operating at full strength.

We have reviewed the results of work on the extraction of protein from vegetable sources for the relief of malnutrition among young children in tropical territories. We consider protein compositions based on groundnuts to be particularly promising for extensive development. The Institute, at our request, is at the present time investigating the technical and economic aspects of a possible large-scale diversion of groundnut meal for this purpose from present commercial outlets. Outside expert opinion is being sought on the economic factors involved, and discussions are being held with international bodies working in this field.

We have also considered during the year the role that the Institute should properly play in the pharmacological assessment of plants from tropical territories, primarily those within the Commonwealth. We believe that there may be potentially valuable new sources of drugs yet to be found which would be of economic benefit to the countries in which the plants are indigenous, and have noted the representations made by overseas governments to the Institute for technical assistance in this field. We have therefore recommended that the Institute should arrange, with assistance as appropriate from other organizations, for facilities to be provided for the pharmacological examination of plant materials.

Approaches have been made to the Institute during the year for research into new outlets for crops such as coffee, sugar and wattle. In considering these requests we have followed the policy that the Institute should not undertake researches of this kind where no profitable line of investigation could be seen or where we considered the present research effort to be adequate.

We have given some attention to publicizing the functions and facilities of the Institute. A brochure has been distributed and we are considering the Institute's publications generally.

In so far as financial considerations permit, the staff of the Institute continues to follow the agreed pattern of overseas visits which we consider essential to its work. We are pleased to know that while on these visits the staff takes every opportunity of bringing the Institute's facilities to the attention of those who are in a position to use them.

CHARLES DODDS,
Chairman

March 1961

REPORT OF THE DIRECTOR OF THE TROPICAL PRODUCTS INSTITUTE FOR 1960

INTRODUCTION

DURING the year the staff complement has been filled and new officers have settled into the Institute.

The economic and long-term research work has been expanded to meet the need that is becoming apparent in countries which are rapidly developing both politically and technologically. This need reflects a trend away from short term enquiries of, for example, a routine analytical nature, which have provided the principal part of the Institute's work in the past, and is more towards research and development problems which laboratories newly set up in these countries cannot undertake.

More important still is the demand for qualified manpower from advanced countries to advise in the territories themselves on setting up laboratories, training personnel, etc., but in this sphere the Institute is able to make only a limited contribution, largely due to financial considerations. However, during the period under review training has been given to visiting workers from five overseas territories who have spent periods of from one week to several months in various sections of the Institute. In all 182 visitors from 49 countries have visited the Institute, and visits have been made by officers from the Institute to 39 overseas territories (Appendix I). One officer of the Institute has been seconded for two years as a chemist to the West African Stored Products Research Unit in Nigeria, and another visited Sweden to inspect part of the equipment for a new pulp and paper laboratory for the Federal Institute of Industrial Research, Nigeria, before it was shipped to Africa. At the request of the Federal Institute it was arranged that this officer should visit Nigeria early in 1961 to superintend the installation of equipment, begin the testing work and give some training to the officers who were to staff the laboratory.

Nine hundrend and two enquiries for advice and assistance have been received from 62 countries (Appendix II), about the same number as in the previous year. These have been increasingly concerned with the economic aspects of development rather than with the fields of analytical and routine advisory work. Almost 25 per cent of all enquiries related to marketing, trade and economic aspects. A further 25 per cent concerned processing methods and machinery, packing, storage and transport and the capital, plant, labour, etc., required for the establishment of small industries. However, although only 10 per cent of the enquiries received during the past year have required laboratory investigation, much of this work has been on a long-term basis and has involved in all three-quarters of the Institute's effort in terms of man-hours.

Copies of the more important market reports and notes on small industries prepared by the Institute were circulated to about 80 different government organizations in 36 different countries.

It appears that once again most assistance was given to the West Indies, Nigeria and Colonial territories in East Africa.

PUBLICITY

Almost 2000 copies of a brochure describing the work of the Institute were distributed in the United Kingdom and overseas to governments and government officers, international organizations, research institutions, etc.

Five broadcasts concerning various aspects of the work of the Institute were made by the B.B.C.'s Overseas Service, three by overseas radio stations, and with the co-operation of the Central Office of Information a number of articles were circulated to overseas territories for publication in local newspapers.

SENIOR STAFF CHANGES

In June Dr. R. A. E. Galley resigned from the post of Director, which he had held since 1953, to take up an appointment with the Shell group as Research Director and Manager of the Woodstock Agricultural Research Centre at Sittingbourne, Kent. His successor, Mr. E. S. Hiscocks, M.Sc., F.R.I.C., formerly Director of the United Kingdom Scientific Mission in Washington, took up his appointment as Director of the Institute in November. In the interim period Dr. P. C. Spensley, Assistant Director, Administration and Development Division, acted as Director.

Mr. T. A. Oxley transferred from the post of Assistant Director, Advisory Division, to the Civil Service Commission in November. Until his post is filled Dr. L. Horton, Assistant Director, Research Division, is also acting as Assistant Director of the Advisory Division.

FOODS AND FEEDINGSTUFFS

RICE

Work on the correlation between sterile glume length and protein content of Nigerian rice (Annual Report 1959, p. 8) has continued, and shown slight evidence that long glumed varieties of *Oryza sativa* may have a higher protein content than the short glumed varieties, though the differences are small. No correlation between grain shape and protein content has been found.

The effect of storage (at 86°F) on the cooking quality of Nigerian rice is under investigation, while some further work has shown that the cooking quality of rice can be improved by the use of non-toxic surfactants.

Three territories, i.e., the Eastern Region of Nigeria, Swaziland and British Guiana, were given information on major trends in the world rice trade and advised on the particular markets in which they might dispose of exportable surpluses. A full report was prepared for British Guiana on the requirements of the United Kingdom market, including the prospects for the type of rice for which British Guiana is best known, i.e. parboiled rice.

COCOA

In answer to an enquiry from the West Indies on the possibility of establishing a chocolate manufacturing industry there, a report was prepared covering such aspects as the manufacturing, processing, raw materials, capital and labour requirements. The enquirer was informed that if the manufacture of chocolate was based on the local production of cocoa beans, beans from other sources would very probably be required for blending to produce a satisfactory product. It was suggested that if local consumption were likely to be below the

level necessary to keep a plant of the minimum economic size employed, then it might be preferable to establish a moulding plant to produce chocolate bars from imported chocolate couverture.

COFFEE

World production of coffee is far above the level at which producing countries have agreed to limit their exports in order to avoid overloading the market. Under these conditions a low grade product is the first to suffer, and the Institute has been asked to investigate possible alternative, non-beverage, uses for one such coffee for which there is at present no market. A preliminary analysis of the beans showed the presence of nearly 12 per cent of oil, but its high proportion (10 per cent) of unsaponifiable matter rendered it of doubtful value as an edible oil, although possible outlets might exist in the paint and soap industries. Other uses of the coffee which were considered included the extraction of caffeine, use as an animal feeding-stuff or as fertilizer, and as a source of tannin, but in each case there were serious disadvantages. This work has therefore been discontinued.

Enquiries from tropical countries on the process used for the manufacture of soluble coffee powder ("Instant Coffee") have increased during the past year.

SUGAR

Proposals were being considered in one overseas territory for the establishment of a sugar refinery and the advice of the Institute was sought regarding the probable future trend of sugar consumption in the territory. A number of forecasts using different statistical techniques were made and the enquirer was advised that it seemed reasonable to assume that local consumption would provide a market for the entire output of a factory of the size proposed.

An enquiry was received from Fiji regarding the establishment of a small-scale factory for the manufacture of high-boiled sugar confectionery. Information was supplied on the plant, capital, raw materials and processes involved in such an industry, and a list of firms making machinery for the purpose was supplied. It was emphasized that although Fiji is a producer of raw sugar, the refined sugar that is required for confectionery manufacture would have to be imported. The need for experienced supervision to ensure a good, consistent quality in the finished sweets was stressed. Particulars were therefore given of a full-time course on chocolate and sugar confectionery which is provided in the United Kingdom.

SURFACE ACTIVE AGENTS DERIVED FROM SUGAR

The investigation directed towards the preparation of new types of surface-active agents based upon sugar (Annual Report 1959, p. 17) has continued.

A number of papers and patents have appeared in which is described the preparation of sucrose esters, such as the stearate. Although the products exhibit useful surface activity, their application appears to be limited by their low solubility in water. Attempts have accordingly been made to convert sucrose stearate into derivatives having greater solubility in water.

Attempts to prepare phosphate derivatives of sucrose stearate were unsuccessful. A commercial sample of sucrose stearate consisting essentially of the

mono- and di-esters did not react with triethyl phosphate and, on treatment with phosphorus oxychloride in pyridine, inversion of the sucrose moiety occurred, with the formation of hygroscopic syrups (sucrose derivatives have been found to be inverted by pyridine hydrochloride in anhydrous pyridine). The preparation of sulphate derivatives was also studied, but sucrose stearate did not react with the pyridine-sulphur trioxide complex (which is used for the sulphation of mono- and di-glycerides) in pyridine solution at temperatures below 75°C; at 100°C inversion occurred. To determine whether sulphation would take place at higher temperatures, a sample of glucose palmitate was prepared from glucose and palmitoyl chloride. However, when this ester was treated with the pyridine-sulphur trioxide complex, even at 100°C, the unchanged glucose palmitate was recovered.

Sucrose stearate was found to react with succinic anhydride in pyridine solution, to give a product in which partial replacement of the hydroxyl groups of the carbohydrate by the grouping $OCOCH_2CH_2CO_2H$ had occurred (analysis indicated an average of 1·3 molecules of succinic anhydride per molecule of sucrose stearate). This product could be recrystallized from ethanol, but some solvolysis of the succinate groups took place. After this work had been carried out, a patent (U.K. patent 843,067) appeared which described the reaction of carbohydrate esters such as sucrose stearate with phthalic, succinic or maleic anhydrides in dimethylformamide solution in the presence of potassium carbonate. A comparison is being made between the properties of products produced at the Institute and those of the materials described in the patent, and reasons for the differences are being sought.

MOLASSES

During the extraction of sugar from the sugar cane large quantities of molasses are produced. These are normally mainly exported for cattle feeding, but are also a source of a number of products, notably alcohol. In response to an enquiry regarding the manufacture of power alcohol from molasses, estimates were provided of the probable cost of plant to process the molasses likely to be available and of the labour which would be required to run the plant. It was pointed out that if this plant were to be run throughout the year some means of storing the carry-over of molasses from the crushing season would be necessary. Allowance would also have to be made for loss of import duty on imported petrol.

HONEY

Three samples of honey from Fiji were examined in response to an enquiry concerning the reason for differences in their "creaming" or granulating properties. These properties are determined by the proportion of dextrose present, a lower proportion being present in a clear honey than in an opaque "creamed" honey where the dextrose is suspended in crystalline form in a syrup of the more soluble sugars. Analyses of the samples showed significant differences in the ratios of dextrose to total sugars present, confirming that these were in fact the reasons for the differences.

SEAWEED

Samples of "Brown" seaweeds (*Phaeophyceae*) and "Red" seaweeds (*Rhodophyceae*), from Singapore, were examined with a view to their commercial exploitation as sources of alginic acid and agar-agar respectively. These products have many applications. Alginic acid is used principally as a stabilizer in ice-cream and as a thickening agent in foods, and agar-agar for medicinal, pharmaceutical and industrial purposes which make use of its gelling and stabilizing properties.

In conjunction with this investigation a report was prepared on the market prospects for agar-agar. Information was supplied on the production, trade and prices of the material and the qualities which are required by buyers. It was pointed out that although the trade is highly competitive, Commonwealth producers have the advantage of tariff protection in the United Kingdom market and any new Commonwealth supplier might well obtain a share of the market if the requirements as to quality could be met. A report on the market in the United Kingdom for seaweeds for use in the production of alginic acid is being prepared.

FEEDINGSTUFFS

Amino-acid analyses of two meat powders from Kenya were carried out by the method of Moore, Spackman and Stein (*Analytical Chemistry*, 1958, **30**, No. 7, 1185). The meat powders had been prepared in Kenya by two different methods: (*a*) reduced temperature preparation and (*b*) normal method of production using higher temperature. Meat powder (*a*) was found to be slightly superior to powder (*b*) with regard to quantities of total amino-acid present. The amino-acid composition of a number of East African feeding-stuffs is also being determined.

Feeding trials by a commercial firm on sheep, poultry and pigs were arranged to determine the suitability of velvet beans from Tanganyika as ingredients in animal and poultry foods. As the beans were found to be neither particularly palatable nor a very good source of nutrients they were considered unsuitable as an ingredient in animal feedingstuffs in the United Kingdom.

VEGETABLE PROTEIN FOR THE RELIEF OF MALNUTRITION

A project of potential major importance to the underdeveloped territories of Africa is concerned with the use of vegetable protein for the relief of malnutrition. One of the main causes of sickness, disability and death in Africa at the present time is malnutrition due to a shortage of protein. Over the African continent as a whole some 30 per cent of the children born alive die before the age of five; in some areas the figure is as high as 60 per cent. The World Health Organization report published in 1952, following a study of protein deficiency in Africa, stated that "It would not be too far-fetched to attribute to protein deficiency, at least in part, the backwardness of the African people".

A study of the literature, particularly in relation to local African diets, established that certain vegetable proteins are as nutritionally valuable as animal proteins, and that a particularly useful source in Africa is the groundnut. Statistics of groundnut production in African Commonwealth and Colonial territories were accordingly compiled and revealed that total current production

is more than sufficient to meet the need for supplementary protein of the most nutritionally vulnerable age group, i.e. that of 1-5 years, in these territories as a whole. A preliminary study was then made on certain economic aspects of the use of groundnuts to remedy protein deficiency. These included the capital costs involved in manufacturing a groundnut meal suitable for human consumption; the cost of raw material; problems relating to distribution of the meal; and the disposal of the large quantities of oil which would result from the processing of groundnuts on the scale envisaged. Work on this project is being continued.

FRUIT AND VEGETABLE PRODUCTS

MALAYAN PINEAPPLE JUICE

Flavour

The flavour of Malayan pineapple juice differs from that of Hawaiian and South African juices and the producers have asked the Institute to investigate the reasons for this difference. One possible reason is that the flavouring constituents of the Malayan fruit may differ either qualitatively or quantitatively. An alternative reason is that the processing methods used in the production of canned juice may affect the content of volatile constituents largely responsible for flavour. The first stage of this investigation consisting of the identification of the amino-acids, other acids, sugars and carbonyl compounds has been concluded.

Amino-acids were extracted from the juice by means of a cation exchange resin, other acids by an anion exchange resin and individual compounds identified by paper chromatography. Sugars in the effluent from the anion-exchange column were also identified by paper chromatography.

Aqueous concentrates containing the volatile constituents of the juice were obtained by distillation under reduced pressure in a "cyclone" evaporator. The distillates were collected in cold traps except in the case of those intended for use in the study of the carbonyl compounds which were collected in traps containing 2, 4-dinitrophenylhydrazine in hydrochloric acid.

The 2, 4-dinitrophenylhydrazones were examined by reverse-phase paper chromatography using an N-dimethyl-formamide/decalin solvent system.

Fourteen amino acids, 5 other acids, 3 sugars and 4 volatile carbonyl compounds have been detected and in most cases identified.

There is at present no practicable method of examining esters by paper chromatography and these will be the subject of further work using gas chromatography.

Storage

The investigation of the darkening of concentrated pineapple juice in storage, due to a "browning reaction" (Annual Report 1959, p. 9) has been continued. The juice had been concentrated to 68° Brix and quantities of sulphur dioxide varying from 200 to 1000 p.p.m. had been added. It was found by the Institute that 1000 p.p.m. of added sulphur dioxide inhibited browning for thirteen weeks at a storage temperature of 25°C and for six weeks at 30°C, but at 35°C the juice darkened very rapidly. With the concentrations of sulphur dioxide used, storage at high temperatures was clearly impracticable.

Amino-acid investigations on samples to which no sulphur dioxide had been added showed that aspartic acid, serine, glutamic acid and threonine decreased considerably when the concentrate was stored at 35°C, while α-alanine decreased slightly. The total loss of amino acids at this temperature was 3·71 mg/g or 55 per cent of the quantities originally present. Two ninhydrin reactive compounds were produced during browning and these accounted for much of the loss of the normal amino-acids.

CANNED FRUIT PRODUCTS

Quality assessments of canned citrus products (grapefruit segments and grapefruit and orange juices) from the West Indies and British Honduras were undertaken. All the samples examined were of satisfactory quality and comparable to similar products on the United Kingdom market from other countries.

PROCESSING AND PREPARATION OF FRUIT AND VEGETABLE PRODUCTS

A problem in many countries is the disposal of seasonal supplies of surplus fruits and vegetables. Enquirers in Fiji and Nyasaland were given details of equipment required to set up a small-scale canning line and the minimum output necessary for such equipment to operate economically. Small-scale canning of surplus fresh fruits and vegetables is not generally recommended, as the quality and quantity of the produce available are not likely to be sufficient for effective processing. As a result of other enquiries relating to the processing and preparation of fruit and vegetable products, advice has been given to Kenya on packing pineapple slices in non-rigid containers, and on preparing and packing dates; to Dominica on utilizing avocado pears; to Singapore on preparing cashew apple wine and to Aden and Tanganyika on producing tomato paste or purée.

PROSPECTS FOR DEVELOPING FRUITS AND VEGETABLES FOR EXPORT

To assist overseas official departments in assessing the export possibilities of their crops, notes have been prepared and circulated on the market prospects for various fruit and vegetable commodities, including pineapples and their products, tomatoes and cucumbers, canned papaw, certain guava products and fruit nectars, West Indian cherry juice and Maltese new potatoes.

A note has also been circulated on the development of outlets for bananas by processing, and during the year information has been supplied on banana products to Fiji, Jamaica, Trinidad and Grenada.

Until recently the only banana product with a regular market in international trade has been the dried fruit or "figs" for which outlets have always been limited, with little room for new production. There would appear to be scope for new methods of dehydration in the improvement of banana products if the processes can be operated economically with this fruit. An interesting development is the manufacture of banana purée in the Dominican Republic, mainly for the American market, but the current demand outside the United States appears to be small.

Should the processing of bananas develop to any great extent there would become available quantities of skins, the utilization of which might make a significant contribution to the industry. With this object in mind, an investigation has been started at the Institute on the banana skin as a possible source of chemicals for industrial or other use.

Extraction of the skin with solvent yielded a yellow wax which constitutes 8 per cent by weight of the skin. The reactions and analytical constants of the wax as determined by micro-methods (acid value mgKOH/g wax 2·5; saponification value mgKOH/g wax 71; unsaponifiable matter per cent wax 78) suggests that the wax might be a possible source of steroids.

Adsorption chromatography of the wax has yielded so far two ketones, the properties of which suggest that they are steroid or triterpenoid. Work is in progress to determine the structure of these and other constituents of the wax.

IMPORTS OF FRESH FRUITS AND VEGETABLES

During the past year liaison has been maintained with Covent Garden Market over consignments of fruit and vegetable produce received there from overseas territories, and regular reports have been supplied to the departments of agriculture concerned regarding the condition of the produce on display and commercial comments. The produce included pineapples, mangoes, passion fruit, strawberries, Cape gooseberries, french beans and asparagus from Kenya, and tomatoes and pineapples from Malta and Tanganyika respectively.

IMPORTED CUT FLOWERS

For several years Maltese growers have exported cut flowers to this country by air freight and the Institute provided the Department of Agriculture, Malta, with an up-to-date review of the trade and suggestions as to how the quality of certain types of Maltese blooms could be improved. Interest has now arisen in Jamaica and general information regarding the trade, packing and presentation of blooms was supplied, although it was emphasized that the market for cut flowers in the United Kingdom is a very competitive one.

OILSEEDS, OILS AND FATS

UTILIZATION OF COCONUT

In many parts of the tropics there is an excess of coconuts over those required for local consumption and the surplus is transformed into copra by drying either in the open air or in special kilns. Much of this copra is exported and in the United Kingdom is usually sold on the basis of appearance and weight. Although it is generally true that the more attractive parcels of copra produce the better oil, a sounder method of quality assessment would be on the basis of the value of oil and cake which can be milled from the copra.

Samples of copra from Tonga have therefore been examined in an attempt to ascertain how accurately Tongan methods of grading can be linked with the value attached to the oil and cake manufactured from any particular grade.

Since a large proportion of the world's copra is manufactured by the small peasant producer, control of quality presents a problem. Moisture content is a critical factor in the keeping qualities of copra and largely determines the

extent of mould activity. The Institute is therefore studying the development of an easily operated moisture meter which would give a sufficiently accurate measure of the water content of the material and, in collaboration with the Pest Infestation Laboratory of the Agricultural Research Council, attempts are being made to modify a meter originally developed at that Laboratory for grain. The meter consists of a head with two stainless steel spikes connected to an electrical resistance meter of the hand generator type. When the spikes are pushed into the copra and the handle of the generator turned, the electrical resistance of the copra between the spikes is measured and the water content can be read from the dial.

Preliminary results are promising and encouraging reports have been received on a number of meters at present on trial in the tropics.

Advice has been given to various territories on alternative uses for the coconut, in particular its utilization for the manufacture of desiccated coconut, and on the advice of the Institute a factory for the manufacture of desiccated coconut will shortly be erected in Tonga.

BLEACHABILITY OF PALM OIL

Investigations concerning the difficulty of bleaching Nigerian palm oil (Report 1959, p. 6) have continued, being mainly concerned with attempts to verify and extend earlier conclusions. Thus samples of oil from both bruised and unbruised fruit, extracted at various times after harvesting, were supplied by the Cameroons Development Corporation from the four types of palm tree cultivated in their plantations and were subjected to the standard heat and earth bleaching tests developed at the Institute. Results confirmed earlier conclusions, namely that palm oil with a low carotene content is less likely to deteriorate in bleachability than oil having a high carotene content; bleachability deteriorates when there is a delay in processing the fruit; the deterioration of bleachability is far less noticeable with heat bleaching than with earth bleaching.

Close liaison is maintained with the West African Stored Products Research Unit, and at their invitation the Officer at the Institute who directs this work visited them to discuss the overall integration of the programme.

The practical implications of the Institute's work on palm oil are as follows: —

1. Since excellent oil has been produced by both the Institute and the West African Stored Products Research Unit it should be possible to introduce improved methods of processing at the peasant level, although it is not yet known whether this can be done economically. Increased care would raise production costs, but increased revenue would result from the lower acidity and from the bonus for better bleachability. A costed trial has been suggested.

2. Special bleachable oil can be produced fairly easily on the plantation scale. The Belgian Congo has already done this and marketed the product commercially.

3. As a long term project strains of oil palm yielding oil containing 500 p.p.m. or less of carotene should be introduced to replace existing trees yielding highly pigmented oil.

CONSTITUTION OF TUNG OILS

Tung oil is obtained from two species of *Aleurites*, namely *A. fordii* and *A. montana*. The oil from *A. fordii* is more acceptable to the paint and plastics industries than that from *A. montana* largely on account of its shorter gelling time. Owing to the fact that *A. montana* will thrive under tropical conditions better than *A. fordii*, growings in Nyasaland are restricted to the former species. An investigation is therefore being made to determine the reason for this difference in gelation time with a view to improving that of the oil of *A. montana*.

The gelation of tung oil involves the conversion of α-elaeostearic acid into the β-form. Certain features of this reaction suggested that it might be influenced very strongly by the presence of metallic ions or organo-metallic complexes. A careful search failed to reveal their presence, and so attention has been turned to the relationship between gelation time and oil composition. This is to be investigated in two stages: examination of the unsaponifiable constituents—now in progress, and separation and estimation of the component glycerides.

The unsaponifiable matter has been separated (principally by adsorption and paper chromatography) into five fractions, three of which have been identified almost conclusively as α-tocopherol, γ-tocopherol, and Δ5 stigmastene-3β-ol ("β-sitosterol"). A fourth fraction appears to be composed of the oxidation product(s) of the tocopherols, and attempts are being made to avoid the formation of this component. These four fractions account for 85-90 per cent of the unsaponifiable matter of the *A. montana* oil studied, the sterol being present to the extent of 40-45 per cent. The fifth fraction, which is in the initial stages of examination, possesses some unsaturation.

MICROBIOLOGY

An important factor in assessing the quality and value of oilseeds, particularly those used as sources of edible fats, is the acidity of the oil. A factor which contributes to the development of acidity is attack by moulds, and the West African Stored Products Research Unit has submitted to the Institute samples of various fungi which may have played a part in the development of unexpectedly high values for free fatty acid in some bulk stores of palm oil in Nigeria. These fungi are at present in culture for specific identification and various media for the study of lipolytic moulds are under examination. One of the principal genera concerned in lipolysis is *Aspergillus*.

Similar work is being carried out in connection with groundnuts and palm kernels.

INTERNATIONAL COLLABORATION

When fats and oilseeds are marketed in several countries it is essential that the methods of analysis employed for their examination be standardized on an international basis. Arising from the Institute's representation on the Oil and Fat Division of the International Union of Pure and Applied Chemistry and on the International Standards Organization, samples of various oils have been examined, in collaboration with workers in this country and overseas, using methods which were under review. Studies have included methods for determining monoglycerides, water, the solidification curve of fats, and fatty acid

composition (using recently developed absorption methods). The determination of the carbonyl value of fats has also been studied and a tentative method recommended for international adoption.

The newer methods of gas-liquid chromatography, as applied to fatty acids, have also been examined, and applied not only to samples circulated in connection with international collaborative tests, but also to various less common oilseeds and oleaginous materials under study at the Institute. A case in which this method has proved most valuable is in detecting the adulteration of spermaceti with hydrogenated sperm oil.

EURYGASTER INTEGRICEPS

This insect, known as the Sunn Pest, is found in Turkey and Iran and causes great damage by attacking growing grain. Russian workers have claimed that fluctuations in numbers are preceded by changes in the internal physiological condition of the insect. Hitherto this method of forecasting the severity of an insect attack has not been tried outside the U.S.S.R.

Usually some 30 to 35 per cent of the body weight of the insect consists of fat, most of it a reserve supply intended to tide the insect over the long resting and hibernation periods when it cannot obtain food. The Institute has been investigating the way the fat content and composition varies during the life cycle. The insects are treated individually in a specially-designed micro-extraction apparatus, the extracted fat weighed, and the iodine value determined. Analyses are also being carried out by gas-liquid chromatography, a method capable of dealing with extremely small quantities of fat. The study has not proceeded sufficiently far to enable any conclusion to be presented.

ESSENTIAL OILS, SPICES, GUMS AND RESINS

DEVELOPMENT OF NEW SOURCES OF ESSENTIAL OILS

Naval stores from Mauritius

In recent years the Institute has brought to the attention of Commonwealth territories the need of United Kingdom users for new sources of naval stores (turpentine and rosin). Interest was aroused in Mauritius, and they are now hoping to improve the island's economy by founding a small naval stores industry on existing plantations of *Pinus elliottii*. To this end 300 gallons of pine oleo-resin from Mauritius, obtained by tapping part of the new plantations of *Pinus elliottii*, were examined at the Institute on a pilot-plant scale to see whether the material would yield good commercial qualities of turpentine and rosin. The oleo-resin was distilled in a large stainless steel still, and the molten rosin run into galvanized iron trays. The products obtained were found to be comparable to American turpentine and rosin in both yield and quality and were commercially acceptable.

An interesting feature was that the turpentine contained over 50 per cent of β-pinene. Turpentines with a high β-pinene content are rare, and the need for them may increase since this isolate has become important as a starting material for the manufacture of certain perfumery compounds. α-pinene, of which the turpentine contained in the region of 40 per cent, is a more readily available commodity and therefore of less potential value.

The work has shown that a naval stores industry could form a useful new development for Mauritius. Unfortunately the island suffered from two serious cyclones earlier in the year, and it will be some time before existing young stands of *Pinus elliottii* will reach tappable size over an area large enough to support a local industry.

Nindi oil from Northern Rhodesia

Nindi oil, from *Aeolanthus gamwelliae*, has been produced spasmodically in very small quantities by a few European farmers in the Abercorn area of Northern Rhodesia ever since the plant was discovered in the early 1930's. At the time of its discovery a sample of oil distilled from the flowers was examined by the Imperial Institute and found to be generally similar to palmarosa oil and to have an unusually high content of geraniol, a very useful constituent in perfumery.

During a visit to this area by a member of the Institute staff earlier this year, it was decided in consultations with the Development Commissioner and with European growers that an attempt should be made to develop this oil further. It appears to be a particularly promising crop as the Northern Province, to which the plant is indigenous, is isolated from the main lines of transport and is in need of cash crops with a high price to bulk ratio.

To stimulate trade interest, samples of oil distilled from flowers grown on the Agricultural Department's trial grounds and by European farmers from their own plantings have been sent to the Institute for analysis and trade evaluation. Those submitted to the Perfumery Department of a soap manufacturing firm, which was the largest user of palmarosa oil until its price became prohibitive, were well received. The firm is willing to buy trial consignments of the oil for use, first in toilet preparations, and later, if quality can be maintained at a reasonable price, in soaps.

In consultation with the Institute a firm of still manufacturers has designed a small scale distillation unit for the oil, and it is hoped to install two of these units in the Northern Province of Northern Rhodesia to produce consignments of oil on the hundredweight scale.

One feature of the oil has not yet been resolved. The oil preferred by the soap perfumers was that distilled by the Agricultural Department using an apparatus fitted for cohobation, i.e. return of the distillation water to the still after separation of the oil, as recommended by the Institute. This method gave a higher yield of oil than that obtained by European growers using older distillation apparatus not fitted for cohobation, but the reason for its superior quality could not be detected either by general chemical methods of analysis or by gas chromatography. The differences in composition of these two oils may lie in minute amounts of certain water-soluble constituents which are absent from the oil distilled without cohobation, and efforts will be made to detect these.

EXAMINATION OF THE COMPOSITION OF ESSENTIAL OILS BY GAS CHROMATOGRAPHY

Geranium oil from Kenya

At the suggestion of the Institute, Bourbon geranium plants from Reunion, the established source of the geranium oil known to commerce, were introduced

to Kenya a few years ago in the hope of providing a valuable new cash crop. Samples of geranium oil distilled from the leaves of established crops in Kenya have been favourably received in trade circles in the United Kingdom, and a detailed study of the oil is now being undertaken at the Institute.

The first stage was the separation of the hydrocarbons from the oxygenated compounds by means of silica gel, the hydrocarbons being eluted with *n*-hexane and then the oxygenated compounds with ethyl acetate. The two fractions were examined by gas chromatography.

The constituents of the two fractions were classified by comparing chromatograms of the oil before and after treatment with reagents which are specific for certain functional groups, and cause the disappearance of the appropriate peaks.

Individual compounds were identified by determining the relative retention volumes of authentic specimens of compounds which were thought to be present and comparing them with those of the peaks in the chromatogram of the oil. Alcohols (citronellol, geraniol, linalol and nerol) and esters (citronellyl acetate, citronellyl formate, geranyl acetate and geranyl formate) were found to constitute about 75 per cent of the original oil; an aldehyde and a ketone together form about 12 per cent of the oil, and the remaining 13 per cent consists almost entirely of terpene hydrocarbons.

The quantitative determination of citronellol and geraniol is of considerable industrial interest, but chemical methods of analysis give only a value for total alcohols. A method for the determination of these compounds individually by gas chromatography is therefore being developed.

Because of the large number of close peaks in the chromatogram of geranium oil, there was some difficulty in finding a suitable internal standard. Polyethylene glycol 400 was used as the stationary phase and, as this retards aromatic and hydroxyl compounds very strongly, certain alcohols and phenols were tested as standard substances. These were not satisfactory with such a highly polar stationary phase and a search was then made for an ester whose aromatic character and high boiling point would counteract the relatively low polarity of the ester group. Ten esters were prepared and tested. 3-phenylpropyl acetate was found to emerge just before the last constituent of the oil (i.e. geraniol); the propionate was then tried and was found to be satisfactory.

A pure specimen of geraniol was prepared for reference purposes from commercial geraniol by liquid adsorption chromatography.

Variations which occur in the quality of Kenya Bourbon geranium oil may be caused by the occasional distillation of plants which are either too young or too old, and a series of experimental distillations is therefore being carried out in Kenya using plants at various stages of maturity, the oils being examined at the Institute by gas chromatography. The four examples examined so far show that as the plant matures the proportions of citronellol and the most volatile oxygenated compounds (probably ethers) increase, while the proportion of linalol decreases.

IMPROVEMENT OF THE QUALITY AND FLAVOUR OF SPICES

Cinnamon bark from the Seychelles

For some 40 years past, cinnamon leaf oil and, to a much smaller extent, cinnamon bark, have constituted one of the major sources of income to the Seychelles. The bark originally exported, however, was the whole bark of the

tree, and was inferior in appearance and flavour to the cinnamon produced in Ceylon. Since 1953, when the market for cinnamon leaf oil appeared likely to suffer a considerable and permanent decline, efforts have been directed towards the production of cinnamon bark in the form prepared in Ceylon, i.e. thin quills composed of the dried inner bark only. The Department of Agriculture has been provided with advice on the method of quilling, and samples and small commercial consignments of quills from the Seychelles have shown that the Department has acquired a high degree of skill in quill preparation; commercial production also has improved rapidly in quality.

Flavour, however, the most important property of the quills, was found to be very variable and generally much weaker than that of Ceylon cinnamon. Determination of the content of volatile oil (the source of the flavour) of a few samples gave values ranging from 0·25 to 1·1 per cent, compared with 1 to 2 per cent for Ceylon cinnamon oil. The *British Pharmacopoeia* stipulates a minimum of 1 per cent, so that Seychelles quills are, at present, unacceptable for pharmaceutical purposes, and for other purposes where the pharmaceutical grade is normally used. The low and variable oil content may be due to varietal differences, soil and climatic conditions, incorrect harvesting or to a combination of these factors. One of the Institute's staff visited the Seychelles in April of this year to study the conditions under which the cinnamon was grown and methods of harvesting and preparing the bark. It was arranged that samples of bark should be collected for examination by the Institute, the samples to be taken from three selected areas of different soil types, from stems of various ages harvested at different times of the year.

In 1959 seedlings of the Ceylon variety of cinnamon were dispatched to the Seychelles; these plants are growing well, and are now almost large enough to provide sufficient bark for examination.

MARKETING OF GUM ARABIC

A report was prepared, with particular reference to Kenya, on world production of and trade in gum arabic, its uses and the effect which substitutes have had on demand. Particular attention was paid to quality, grading and packing requirements, the enquirer being informed that the demand is mainly for a carefully graded and cleaned high quality product. If this high quality cannot be achieved, it was suggested that an outlet for a lower grade product might be found in the Indian market. There is at present no commercial exploitation of Kenya's gum arabic resources.

DRUGS

SENNA

At the Institute's request, experimental cultivation of senna (*Cassia senna*) has been initiated in several African territories, with a view to supplementing supplies of Alexandrian senna now obtained from the Sudan region. The plants grow well from seed, but it is too early to say whether they will yield leaves and pods of a quality suitable for pharmaceutical purposes.

YAMS

Some species of non-edible *Dioscorea* yams are of potential value as sources of steroidal sapogenins (e.g. diosgenin) that may be used as the starting point for the manufacture of corticosteroids. Three specimens of tubers from Zanzibar were examined in this connection, but did not prove to be of value as the sapogenin content was small (0·2 per cent or less) and substances of steroidal structure were absent as indicated by the infra-red spectrum in the region 850-1000 cm^{-1}. The yams had not been botanically identified.

PHYSIOLOGICALLY ACTIVE SUBSTANCES FROM PLANTS

With the aim of finding new compounds of medicinal value, and new or improved sources of established drugs, work on the isolation of physiologically-active materials from plants is being carried out. The primary purpose of this work is to find new cash crops for underdeveloped tropical territories.

To date 314 plants, comprising herbarium specimens collected in British North Borneo, and samples of fresh leaves from hot house plants at the Royal Botanical Gardens, Kew, have been tested, and 39 have given positive alkaloidal reactions. However, in some cases the indications were not sufficiently definite to show the presence of alkaloids in the plants as nicotine had been used in sprays. Nevertheless, a number of genuine alkaloid-containing plants were found and these are being examined further.

The procedure adopted is for aqueous extracts of selected plants to be submitted to examination at the pharmacological testing unit at Birmingham University which is financed by the Institute. Further chemical work is largely based on the results of these initial tests.

In addition to the routine screening mentioned above, several plants have been examined as a result of a specific request or because definite indications were received as to their promising nature in this work. One request from Tanganyika concerned *Trichodesma zeylanicum*, a plant whose seeds were being considered for use as oilseeds. About 2 per cent of alkaloids on a dry weight basis were found, the major alkaloid being supinine in quantities showing the plant to be the richest known source of this alkaloid. Two other alkaloids were present in much smaller amounts. The presence of supinine is unfortunate if the seeds are being considered for oilseeds since this alkaloid has been shown to cause liver damage and subsequent death in sheep.

PLANT SAMPLES AND PHYTOCHEMISTRY

The service of providing plant material for research work was continued, and during the period under review material was supplied to 15 universities or colleges, the Medical Research Council, two overseas research institutes and to sections within the Institute itself. Research outside the Institute on the plant materials includes investigations on the chemistry of plants with reputed insecticidal properties (Dr. L. Crombie, Chemistry Department, King's College, London), on the alkaloids of *Strychnos* and *Alstonia* spp. (Dr. A. R. Battersby, Department of Organic Chemistry, University of Bristol), on the alkaloids of Greenheart, *Ocotea rodiei* (Dr. M. F. Grunden, The Queens University of Belfast) and on the alkaloid *yohimbin* from *Corynanthe macroceras* (Dr. J. E. Heesterman, Koninklijk Institut Voor de Tropen, Amsterdam).

INSECTICIDES

A considerable amount of work has again been carried out on the determination of insecticide residues in various tropical products, on the examination of insecticidal formulations, and in collaborative work on analytical methods. Residue determinations were made on malathion and BHC in groundnuts, maize and guinea-corn; DDT and BHC in maize; DDT and malathion in ginger; and DDT in green and fired tea.

Collaboration with the Expert Committee on Insecticides of the World Health Organization has continued, information and technical comments being furnished on various aspects of pesticide formulations and specifications.

PYRETHRUM

Sampling

The raw material for the production of pyrethrum extract consists of the dried flower-heads of *Chrysanthemum cinerariifolium*, containing about 1·5 per cent of the insecticidal pyrethrins. The flowers and extract comprised Kenya's fourth largest export in 1959. Consignments delivered to the factory represent a bulking of dried flower-heads from numerous growers, and there is inevitably some variation in the material since pyrethrin content is affected by such factors as strain of flowers, maturity at picking and care during drying. Consignments are bought and sold on the basis of pyrethrin content of the flowers, and a knowledge of this content is also needed in order to check the efficiency of the extraction process. It is necessary to be able to obtain representative samples from consignments of flowers to determine pyrethrin content, but the variability of consignments frequently causes sampling problems. Although various methods of sampling have been tried in the past, considerable difficulties have arisen from time to time in East Africa through discrepancies in results obtained by buyers and sellers.

Accordingly, at the end of 1959 one of the principal extract producers decided that the whole question of pyrethrum sampling should be properly studied. A member of the Statistical Department of Rothamsted Experimental Station spent several weeks in Kenya supervising the investigation and the numerous samples obtained were flown to the Institute for determination of pyrethrin content. A rapid spectrophotometric method was used and in all about 500 determinations of "total pyrethrins" were made.

The final report, which has been published in *Tropical Science* (**Vol. II**, No. IV, 1960), indicated the various sources of discrepancy in existing sampling methods, and showed how improved procedures might be designed.

Biological activity

Work on the biological activity of the esters responsible for the insecticidal activity of pyrethrum, namely pyrethrins I and II, and cinerins I and II (Annual Report 1959, pp. 18-19), has continued. It has, however, been extended particularly to include a study of the effect of synergists on toxicity and knock-down, as commercial pyrethrum insecticides are nearly always formulated with the addition of synergists.

Pure specimens of the four esters were prepared from pyrethrum extracts by partition chromatography on silica gel/plaster of Paris followed by displacement chromatography on alumina. The biological activities of these compounds were measured at Rothamsted Experimental Station.

The synergistic factors and order of relative toxicities of the cinerins and pyrethrins with piperonyl butoxide were measured with varying ratios of synergist to active constituent. Both the synergistic factor and the relative toxicity of a constituent were found to vary with the ratio of synergist to active constituent in a rectilinear manner when plotted on logarithmic paper.

The order of relative toxicity was found to be reversed on addition of the synergist, the cinerins becoming slightly more toxic than the corresponding pyrethrins, and the chrysanthemic esters (pyrethrin I and cinerin I) more toxic than the pyrethrin esters (pyrethrin II and cinerin II).

A study has been started of the evaluation of the quick "knock-down", characteristic of the insecticidal activity of pyrethrum, for the four esters alone and in the presence of synergist. The lines investigated were the "knock-down" and recovery of houseflies treated with pyrethrum extract, alone and when synergized with piperonyl butoxide, and the "knock-down" and toxicity curves of the pyrethrins and cinerins alone and when synergized with piperonyl butoxide.

From the results it was possible to determine the effect of the passage of time on flies treated with a known quantity of pyrethrum, and the dose of active material needed to affect a given percentage of insects (usually 50 per cent) at a given time. The latter figures were plotted against time to give 50 per cent toxicity curves.

In general, at a fixed dose, the toxicity curves of pyrethrum and its constituents are composed of four portions:

(1) a very short latent period, during which a few insects only are knocked down,

(2) the knockdown period during which the number of insects affected rapidly increases to a maximum,

(3) the period of maximum effect, and

(4) the period of recovery.

The duration of each period depends on the dose, the constituent, and the age of the flies used.

The 50 per cent toxicity curves show the knockdown portion as a period during which the doses decrease rapidly to a minimum and the recovery portion as the period during which the insects recovering from the effects of knockdown cause an increase in the required dose.

It was found that pyrethrin II and cinerin II have higher initial knockdown powers and allow faster recoveries than pyrethrin I and cinerin I, but the relative toxicities of pyrethrin II and cinerin II decrease, while those of pyrethrin I and cinerin I increase, with time, so that three hours after treatment the relative toxicities of the four constituents are pyrethrum extract 1·0, pyrethrin I 1·10, pyrethrin II 1·50, cinerin I 0·66 and cinerin II 0·51. The synergistic factors also vary with time, being small during the first 15 minutes after treatment, increasing rapidly during the following 90 minutes or so and then rising very slowly.

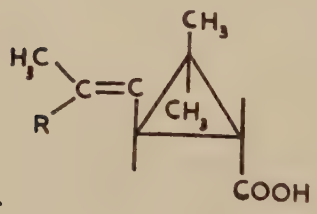
A preliminary analysis of the relative toxicities and synergistic factors of the four constituents and the extract at selected time intervals shows the following features: (i) the synergist increases the number of insects affected, prolongs the period of maximum effect and slows down and reduces recovery to a very considerable extent; (ii) the cinerins are synergized more effectively than the

pyrethrins, and the chrysanthemic esters better than the pyrethric esters; (iii) the limited effect of the synergist on the knockdown activity of the constituents, and its large effect on the recovery of the insects from these poisons, which take place during the first few hours after treatment.

Biosynthesis

The study of some aspects of the biochemistry and physiology of the pyrethrum plant has continued. In particular, the feeding of 2-(14C) mevalonic acid to the isolated ovules of pyrethrum flowers has led to the improved incorporation of 1·4 per cent of the (+)-isomer of mevalonic acid into the pyrethrins. In order to assess this incorporation accurately the radioactive samples have been converted into the corresponding 2,4-dinitrophenylhydrazones. For comparison, the derivatives were prepared from the pure pyrethrins and cinerins obtained by the chromatographic methods mentioned earlier. Of these four derivatives only those from pyrethrins I and II had previously been reported as crystalline compounds. The other two derivatives have now been crystallized, and have been shown to possess physical properties identical with those of specimens prepared by Dr. M. Elliott at Rothamsted Experimental Station from synthetic samples.

The derivative of pyrethrin II has to be prepared under carefully controlled conditions. In acidic methanol, pyrethrin I readily gives the hydrazone of the intact ester, whereas pyrethrin II is split giving free pyrethric acid (I,R=COO Me) and the 2,4-dinitrophenylhydrazone derivative of pyrethrolone methyl ether (II).



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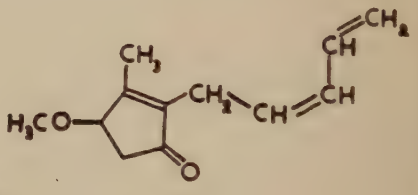

II

This no doubt explains some of the previous failures to prepare this derivative.

This cleavage of pyrethrin II has now been utilized to follow the incorporation of 2-(14C)-mevalonic acid into pyrethrin II. It has been shown, following the total lack of incorporation of radioactivity of 1-(14C)-mevalonic acid into the pyrethrins, that 2-(14C)-mevalonic acid is only incorporated into the acidic moieties of these esters. In contrast, the cyclopentenone alcohols were found to be derived from acetic acid without the mediation of mevalonic acid.

This result is not too surprising since these acids could theoretically be formed by the condensation of two isoprene units. However, there is some novelty in this condensation because the usual precursor of mono-terpenes is geranyl pyrophosphate. Therefore, chrysanthemum mono-carboxylic acid (I,R=CH_3) and chrysanthemum di-carboxylic acid (I,R=COOH) must be formed by the cyclizations of a novel terpenoid precursor.

To confirm this theory the stepwise degradation of these acids is being investigated. Because methods for the degradation of the side chain $-C{:}\,C\langle^{CH_3}_{CH_3}$ are well-known, work is being concentrated on the biologically more interesting side chain of chrysanthemum dicarboxylic acid (I,R=COOH) derived from pyrethric acid (I,R=COO Me) by controlled alkaline hydrolysis, the investigations being carried out on radioactive samples.

Analysis

Colorimetric methods of pyrethrum analysis have been examined for the Pyrethrum Board of Tanganyika, to provide a simple method, requiring the minimum of apparatus, to guide the pyrethrum breeding programme of the Department of Agriculture. None of the published colour reactions for pyrethrins was sufficiently reliable quantitatively to be recommended, but it was found that the well-established spectrophotometric method of pyrethrin analysis can be much simplified. Essentially the improvement is in the extraction stage which has been reduced in time from seven hours to one hour. Examination of 120 samples of East African pyrethrum by both the new and the conventional spectrophotometric methods has led to the conclusion that the new method offers sufficient advantages in both time and simplicity of apparatus, to make it attractive for use in the plant-breeding programme in East Africa.

NICOTINE

A marketing organization in East Africa was interested in the possibilities of setting up a nicotine extraction plant and asked for information regarding the capital and plant required, minimum output and the price which would be realized on the world's markets for nicotine extract as an insecticide. Enquiries which were made in this country, North America and various Continental markets, showed clearly that the demand for nicotine-based insecticides is at present very limited and is, moreover, decreasing. The enquirer was informed, therefore, that any nicotine extraction plant based on an export market was unlikely to succeed. It is understood that the project has accordingly been abandoned.

PHYSICO-CHEMICAL STUDIES

Methods for elemental analysis applicable to vegetable material have been investigated in the course of work on plant nutrition as there is a significant lack of data in this field. The object is to initiate a survey of plant composition, particularly in relation to yield but also taking into account cultivation and fertilizer practices, climate and soil. Given a sufficient number of results to ensure adequate significance, the foundation will thus be laid for the controlled use of plant analysis as a guide to cultivation and fertilizer applications.

For a study of elements present in major amounts, established methods have been applied satisfactorily in the study of potassium, calcium, magnesium, and manganese. Flame emission spectrography has been found to give adequate reproducibility, and lends itself quite readily to a system of automatic operation which can lead to a considerable saving in time.

The micronutrients provide a rather more difficult problem, and much attention has been devoted to this question, particularly with regard to iron, copper, molybdenum and zinc. All these elements can be determined spectrographically, and this is the method preferred in view of the necessity for speedy results, direct current arc excitation providing the requisite sensitivity in the parts per million range.

Methods have been studied for concentrating the trace elements prior to direct current arc analysis. This step is unavoidable because the major elements have been found to interfere with trace element determinations and their presence has precluded the preparation of sufficiently concentrated solutions. It has been found that an extraction of anionic chloro-complexes can be used for the removal of iron, copper, molybdenum and zinc, though application to plant material ash has been found to require the preliminary separation of silica which appears to retain by adsorption a certain proportion of the elements sought. Boron is not covered by this method but the well-known colorimetric methods for this element can be readily applied.

As an alternative to the extraction method above, ion-exchange techniques offer potential advantages, particularly in their ease of manipulation. Many of the published methods have been studied with a view to adapting them to the micronutrient problem.

The application of neutron activation has also been investigated in this connection. The great sensitivity obtainable by this method offered the hope of direct analysis, and the absence of contamination troubles once the sample has been irradiated is a very real advantage. Examination of a sample of coffee leaves which were irradiated at Harwell through the courtesy of the Wantage Research Laboratory confirmed the initial hopes, though it was found that after irradiation separation of the elements was necessary before the final stage of the determination could be carried out. It was therefore decided to defer further work on this method until the other alternatives had been examined more thoroughly.

Reproducibility tests of analytical methods applied to 60 samples of coffee leaves have been performed. Copper contents were determined polarographically, and other nutrients by the methods mentioned earlier.

Of 610 samples examined during the year, 89 have been of pyrethrin distillates and residues submitted by the Pyrethrum Board of Kenya. The ultra-violet absorption spectra were used as a check on purity.

LEATHER AND TANNING MATERIALS

PREPARATION AND PRESERVATION OF RAW HIDES AND SKINS

An investigation was undertaken for the Northern Region, Nigeria, to determine the correlation between soaking times required for arsenicating and baling hides, and subsequent putrefaction. Forty experimental hides, representing ten samples from each of four different soaking periods, were examined and results are almost complete.

Work was carried out on new and improved methods of marking raw hides and skins for export and advice given on various techniques of stamping and branding likely to prove suitable for this purpose in Nigeria.

Liaison work between the trade and the overseas producer was maintained and in this connection a number of visits were made to United Kingdom tanners in order to assess the quality of raw material being received from tropical territories. As an aid to the identification of the causes of faults, particularly those resulting from disease, a collection of pelt and leather reference samples has been started and a number of paired samples showing various diseased conditions in raw and tanned pelt form the nucleus of this collection.

TANNING MATERIALS

Work on tanning materials continued and advice was given on extraction processes and plant for the production of mangrove bark extracts, which are to be used in the tanning industry in British Guiana.

A study of the hides, skins and tanning industries, made by a member of the Institute during a recent visit to East Africa, Nigeria and the Gambia, indicated that there is a growing demand for technical assistance and advice in connection with the production of pickled or semi-tanned pelts for export, and of leather both for export and local shoe and leather goods industries. Steps have therefore been taken to equip the section with apparatus for investigating rural tanning methods and materials.

VEGETABLE FIBRES

SURFACE STRUCTURE OF FIBRES

While man-made fibres present increasing competition to some of the natural fibres, there are certain fields in which the latter are known to have the advantage. One such field is in the manufacture of floor brushes from coir bristle fibre, which has excellent cleaning properties due to the presence of hard siliceous bodies on the fibre surface. The British Brush Manufacturers Research Association consulted the Tropical Products Institute concerning whether polishing coir (which improves the surface appearance) removes these siliceous bodies. A study of the surface structure of the fibres undertaken by the Institute showed that the siliceous stegmata can be removed by prolonged polishing, but probably not by normal commercial methods, and it would not be expected that this very useful surface property of natural vegetable brush fibres would be significantly modified by commercial polishing.

MECHANICAL PROPERTIES OF FIBRES

Many industrial vegetable fibres have not yet suffered to any large extent from competition with man-made fibres, but some inroads into the abaca and sisal markets for rope have been made. The manufacturers of synthetic fibres pay considerable attention to the mechanical properties of their products, and to their translation into yarns and ropes: the modern trend is towards the design of synthetic fibres to give the required product performance.

If natural fibres are to maintain their position, therefore, it is important that an understanding of fibre properties, and the way in which they may best be utilized, should be obtained.

For this reason certain properties of fibres, apart from the conventionally-measured properties of tensile strength and fineness are being investigated.

These include extensibility, work to rupture (energy required to break the fibre) and properties connected with the inherent flaws present within the fibre. The problem is being investigated further by examining the histological structure of fibres and the cause of failure in tension.

Preliminary work on the mechanical properties of vegetable fibres has shown, unexpectedly, little correlation between tensile strength and specimen length with short specimen lengths of sisal. This result is a reflection of the way in which sisal ruptures—not by a single break between the jaws of the testing equipment, but very often by multiple breaks, some of which may be within the jaws themselves. This study is being extended to longer gauge lengths where the effect of breakage within the jaws will be minimized.

Preliminary work on the relationship between the mechanical properties and histological structure of the fibres supports the findings of other workers who have used X-ray techniques that, for coir at least, the extension depends on the angle of orientation of the fibrils in the cell wall of the ultimates. Further work on cell wall structure and its relationship to mechanical properties is in progress and is being extended to include other fibres.

AGAVE FIBRE

A comparison of the tensile strength and fineness of fibre from the fourth-cut of sisal (*Agave sisalana*) and from a newly developed second generation hybrid of *A. amaniensis* and *A. angustifolia* confirms the trends shown by comparison of the previous three cuts. The hybrid is finer than sisal, but there is no significant difference in tensile strengths of the two specimens; the tensile strength and fineness of both specimens decreased with each successive cut. A comparison of the dimensions of the ultimate cells was also carried out. Results so far show surprisingly little difference between the dimensions of the cells of the two specimens.

FIBRE PROCESSING

A report on methods of operation and machines available for the extraction of bast, leaf and fruit fibres is in preparation.

An investigation into the possibility of using sonic or ultrasonic energy for the washing of fibres has shown that while it might be possible to produce a cleaning effect the methods would not be feasible on economic grounds.

BONDED FIBRE MATTRESSES

Work on the bonding of coir fibre with rubber and various synthetic resin latices (Annual Report 1959, p. 22) has been continued, and best results were obtained using rubber latex. Small samples, using continuously curled coir instead of chopped curls, showed some promise and in these products the coir was made to contribute more to the resilience of the final product, thus reducing the amount of rubber required for bonding.

The curls were made by hand-winding, but on a commercial scale efficient machinery for producing continuous curls quickly would be required before products made by this technique could compete economically with mattresses of the chopped-curl type.

IDENTIFICATION

Specimens sent for identification included fibre from a palm, possibly *Trachycarpus*, a sample of fibre from *Agave fourcroydes* and two samples which closely resembled *Agave sisalana*, one the line fibre and the other the tow.

In order to extend methods of identification, studies on the histology of fibres and the effect of variety, climate and soil on ultimate cell dimensions are in progress.

FIBRE PRODUCTION

Enquiries on the cultivation, processing and uses of sisal and by-products, abaca, banana fibre, pineapple fibre, kenaf, ramie, sunn fibre and coir were answered.

Considerable interest has been shown in the production of kenaf and sunn fibre and samples have been submitted for quality assessment. While the poor quality of some of the sunn fibre samples rendered them unsuitable for spinning, with some improvement in quality the fibre would find a limited outlet for paper making.

The Agricultural Department in Tanganyika has been considering the large-scale production of kenaf fibre (*Hibiscus cannabinus*) with a view to establishing a local bag-making industry. Particulars of the territory's present consumption of bags and jute fabrics were supplied and consultations with a firm of textile machinery manufacturers showed that the local demand was sufficient to support a manufacturing unit. Whether such a unit would be economic, however, would depend mainly on the price of raw fibre delivered to the mill, and some indication was given of the proportion of the cost of fibre to the total cost of the bag if production were to be economic. An estimate was also given of the acreage under kenaf which would probably be necessary to keep the bag factory fully employed. The enquirer was advised that in the first place more experiments should be carried out on cultivation to obtain reasonably reliable figures relating to the yields of fibre per acre and the price at which the fibre could be produced.

PULP, PAPER AND BOARD MAKING

PULPING METHODS

During the course of the investigation of hardwoods from British Honduras (Annual Report 1960, p. 13) a modification of the semi-chemical process (Patent Application No. 3892/60) was developed at the Institute. The equipment required is simpler and the volume of "cooking" liquor is less, which leads to reduced chemical consumption. Both of these factors would be of considerable help in the economic running of small-scale plants.

SOFT WOODS FROM KENYA

Several softwoods from Kenya are under investigation with the object of finding a use for the knotty thinnings. The woods concerned are *Pinus patula*, *Pinus radiata* and *Cupressus lusitanica*.

Trials have been made by the neutral sulphite, cold soda and kraft semi-chemical processes. Difficulty has been experienced to a greater or lesser degree in sheet making from all the pulps produced, apparently due to fibres breaking in the pulping process. The reason for this fibre breakage is being investigated.

RESIDUE AFTER PROTEIN EXTRACTION

The vegetable residue left after protein extraction by the Chayen process has been examined for its suitability for the production of a corrugating medium. A high yield of pulp was obtained by mild cold soda semi-chemical and/or refining treatments, but it did not come within the rather exacting specification for corrugating medium.

A lower yield of pulp has been obtained with the neutral sulphite semi-chemical process, but the results of its evaluation as a corrugating medium are not yet available.

PULPING OF HOME GROWN TIMBER

Work on the pulping and pulp evaluation of Sitka Spruce for the Forestry Commission has now been handed over to the Forest Products Research Laboratory, a number of their staff having been trained at the Institute for this purpose.

BOARD MAKING

Experimental equipment for the manufacture and testing of chipboard is due early in 1961. Meanwhile, work has started with the apparatus available on the development of techniques and a study of existing products.

LIGHT WEIGHT CONCRETE

In an investigation of the potential uses of vegetable matter as aggregate in light-weight concrete, some success is being achieved with rice hulls and a method is being developed for the rapid and convenient detection of cement setting retarders in this and other materials.

TECHNICAL ASSISTANCE

The Federal Institute of Industrial Research in Nigeria has been given technical advice on equipping a laboratory to evaluate indigenous fibrous raw materials for their potential use in the manufacture of paper and board. A visit to Nigeria will be made by an officer from the Tropical Products Institute early in 1961 to install the equipment and to train staff.

POWER SOURCES

UTILIZATION OF SOLAR ENERGY

Literature has been studied relating to developments within the entire field of solar energy utilization, but particular attention has been given to those suitable for immediate application in under-developed tropical areas.

FLAT PLATE WATER HEATER

The pipe system of the experimental flat plate water heater was redesigned so that a steady rate of flow could be maintained through the three plates. Tests were carried out using iron, aluminium and copper plates at flow rates varying from 4 to 15 g.p.h.

In general it was found that in London, during periods of moderate to full sunshine (from about 10 a.m. to 2 p.m.), with a collector plate surface of 6 ft by 6 ft, 40 gallons of water could be heated to about 60°C (140°F).

SOLAR STILL

Work was started on an improved type of solar still and application for a provisional patent is being made.

The first model of this still is being tested in Malta and a modified version is in the course of construction.

REFLECTOR TYPE WATER HEATER

Construction of a longitudinal parabolic reflector 6 ft long×3 ft wide was started and a simple sun tracking device made; assembly of the equipment to form a complete unit has yet to be undertaken.

DIFFERENTIAL TEMPERATURE SWITCHES

Two types of differential temperature switch have been devised for controlling flat plate water heaters functioning by forced circulation. The switches automatically start and stop the pump according to intensity of solar radiation.

PLASTIC FLAT-PLATE HEATER

Attempts to use a thin plastic bag in place of metal plates to reduce cost in a normal flat-plate apparatus were unsatisfactory because the hydraulic pressure which developed required the use of expensive thick retaining glass. A heater made of this material could only be used in special circumstances, where an almost horizontal position would be permissible, with a low head of water.

AIR HEATER

Work was started on the construction of a normal type of solar air heater, which consists of a wooden box 5 ft×3 ft×9 in. containing an inner structure of blackened and perforated zinc designed to give a turbulent air flow, and covered with two sheets of glass. An electrically driven fan will be used.

MALTA

A member of the staff has been in Malta since 1st July 1960 to study the utilization of solar energy, in so far as it can be of assistance in the general economy of the island. Certain equipment devised and constructed at the Institute is being tested there under field conditions. Two fully instrumented flat plate water heaters have been erected for research purposes and domestic flat plate heaters designed for installing in private houses and blocks of flats.

EXTRA-MURAL ACTIVITIES

The following are reports on extra-mural work being carried out for the Institute

Natural Products Research Unit in the Department of Chemistry, University College of the West Indies

Studies on the constituents of some West Indian plants

Dr. Ellington left the Unit in January in order to take a lecturing post in the University and his successor will be appointed early in 1961.

The study of West Indian medicinal plants has continued following the lines described in the report for 1959. Since the beginning of the investigation standard extracts of 71 plants have been prepared and submitted to pharmacological testing.

Results have suggested that several plants are worthy of more detailed investigation, and this is now being carried out. A few of the plants examined are mentioned below.

Cissampelos pareira. l-Bebeerine and a second alkaloid, probably hyatine, were isolated from Jamaican specimens of this plant.

Forsteronia floribunda. Several types of physiological activity were found. A compound was obtained from the ethanol extract which is optically active, possesses hydroxyl and carboxyl functions, has a high melting point and gives a positive Liebermann Burchardt reaction. Derivatives were prepared.

Morinda royoc. This is used both medicinally and as a dye-stuff, and was found to contain a mixture of anthraquinone derivatives.

Euphorbia hypericifolia. Preliminary fractionations of extracts were carried out in view of interesting pharmacological observations.

The presence of l-noradrenaline in a West Indian plant was confirmed and it was found to occur in greater concentrations than that extracted from mammalian adrenals.

Pieraena excelsa. Extracts from this plant have been used for insecticidal purposes and contain the bitter principles quassin and neoquassin. The former possesses pharmacological activity and when administered intravenously produces a lowering of the blood pressure of the dog. The chemical structure of these compounds is being studied.

Croton linearis. At least six alkaloids have been found, three of which have been obtained in the crystalline state. Structural studies are in progress.

Phorodendron rubrum. A hypertensive principle and three hypotensive substances, one of which is γ-aminobutyric acid, have been found.

Piper amalgo. Extracts have been found to contain dopamine and γ-aminobutyric acid, and a vasodilator principle which is present is being investigated.

Persea gratissima. Work on the Avocado Pear leaf has continued and further basic substances have been isolated.

A brief survey of the chemical literature relating to the plants listed in the "Flora of Jamaica" by Fawcett and Rendle has been carried out with the co-operation of vacation students. In addition surveys on specific topics have been undertaken as an aid to further investigation.

A vacation student (financed by the Citrus Company of Jamaica) has studied the constitution and utilization of orange oil.

Birmingham University, Department of Pharmacology

Pharmacological testing unit

Plant extracts supplied by various organizations were examined for pharmacological activity using acute toxicity tests and tests on standard organ preparations. Additional tests were carried out where considered necessary. A quantitative haemolysis test has been developed for the estimation of saponins in crude plant extracts. Of 16 "Bush Teas", supplied by the Natural Products Research Unit, University College of the West Indies, several showed toxicity, adrenergic properties, spasmogenic activity or slowing of the heart. One has been selected for further study. Of 60 plant extracts supplied by the Tropical Products Institute none had significant haemolytic action, but a few which produced toxic or spasmogenic effects are to be investigated further.

Tests on the Greenheart alkaloid for Professor Hassall of University College, Swansea, were completed. Particular reference was paid to their possible use as hypotensive agents. The crude alkaloid fraction and two alkaloids isolated from this were found to have some hypotensive action which may be due to the ganglionic blocking effect which they also cause.

A series of antioxidant compounds synthesized at the Torry Research Station of D.S.I.R., and elsewhere, have been tested for toxicity and other pharmacological properties.

Makerere College, Uganda, Department of Agricultural Engineering

Methane fermentation

Mr. W. Boshoff continued his experiments on the production of methane from vegetable matter under tropical conditions. Varying aspects of the fermentation were examined in batch experiments, using dung as a starter and air-dried elephant grass chopped to ½-in. lengths. It was found that: —

(i) The maximum rate of digestion of the grass, and therefore the optimum point at which it should be fed to the starter dung, occurred soon after digestion of the dung itself had commenced, i.e. 5 days after the dung itself had been placed in a digester at 32°C or 15 days at 19-21°C.

(ii) With dung and grass mixed in the ratio of 3:1 the gas yield increased with the volume of substrate to an upper limited of 18 per cent of the volume of the digester.

(iii) Gas yield was not significantly affected by the presence of air, the quantity of water, ranging from 46 per cent to 76 per cent at 32°C or 19-21°C, or the type of water, ranging from swamp water to demineralized water.

(iv) Dung stored in the open deteriorated in starting quality by up to 35 per cent compared with dung stored under a roof.

Experiments showed that liquid from previous batch experiments could be used as the starter when mixed with digested material from the same source, but the liquid can only be used alone if extremely small quantities of new materials are added.

Pilot plant work showed that the gross volume of the digester did not influence the yield per unit volume when both digester volume and load were increased tenfold.

No advantage was gained by cutting elephant grass into $\frac{1}{2}$-in. instead of 6-in. lengths, but daily agitation could increase the yield by as much as 21 per cent.

Makerere College, Uganda, Department of Chemistry

Investigations of steroid and triterpenoid constituents of East African plants

Dioscoreas. Investigations into the identity of various species collected previously were continued. An expedition resulted in the collection of a species not previously recorded in Uganda and this yielded small amounts of pennogenin.

Attempts are being made to determine the causes of differences between stigmasterol isolated from a yam and commercial stigmasterol. The differences occur in the melting points of the acetates and in the stanols (the fully reduced forms of the sterols) obtained by hydrogenation.

Other Plants

A toxic substance discovered in the leaves of a plant responsible for a case of cattle poisoning is now under investigation.

Acid catalysed dehydration of steroid alcohols and related compounds

During the first part of the year Dr. Peal worked in the Dyson Perrins laboratory at Oxford. As a result of his studies on the steroid tertiary alcohols 3γ- and 3β-methylcholesterol, an easier route than the one at present available was developed for the production of the useful 3,5-cyclo-steroids. Since these can be readily converted to 3β-halo steroids this modification also affords a facile route for the preparation of such halo-steroids. The value of the modification has been shown by application to cholesterol, ergosterol, diosgenin and androstenolone.

University of Hong Kong, Department of Chemistry

Chemical investigation of plants of Hong Kong

One hundred and sixty-seven plant species collected from Hong Kong Island and the New Territories have been tested qualitatively for the presence of alkaloids. Thirteen species gave strong positive reactions and attempts are being made to isolate the alkaloids from nine of these. In one case a large-scale extraction is planned.

Birmingham University, Department of Chemistry

Structure of oligosaccharides obtained from Chitin and by synthesis

The work by Mr. J. G. Featherstone under the supervision of Professor M. Stacey has been concluded. The scheme devised to determine the point of union in disaccharides containing an amino-deoxy sugar led to unexpected difficulties and a number of products were obtained whose appearance could not be accounted for satisfactorily.

As the work was intended to include structural studies, it was considered appropriate to include an investigation of the intramolecular hydrogen bonding which can appear between hydroxyl groups and amino groups. Accordingly the physical properties (infra-red and nuclear magnetic resonance spectra) of a number of polyols were studied, in particular pentane-2,4-diol, which was separated into its threo and erythro forms.

Chemical and biochemical syntheses of new antibiotics containing amino- and deoxy-sugars

The investigation by Mr. M. C. Keith has continued under the supervision of Dr. S. A. Barker. Particular attention has been paid to the determination of the structure of methyl 3-0-carbamyl novioside obtained by hydrolysis of the antibiotic novobiocin. Chemical work has been supported by measurements of optical rotation and nuclear magnetic resonance. It was found that upon acetylation in the C_2 position the axial methoxy resonance peak of a glycoside undergoes a shaft of 6 c/s irrespective of the orientation of the acetyl groups, whereas the peak of an equatorial methoxy group remains unchanged. It has been found possible to determine both the group orientations and the particular geometrical configuration (chair form) of the substance.

Leeds University, Department of Leather Industries

Constituents of mangrove bark and related vegetable tanning materials

Mangrove trees constitute the largest potential source of vegetable tanning materials in the world. However, the tannin obtained from the bark is of low quality, being highly astringent and producing a harsh leather of poor colour. The disadvantage of the red colour which is produced even when only small proportions of mangrove extract are used in conjunction with other tanning materials outweighs the advantage of the low price of the extract. The colour of the extracts becomes progressively more intense on exposure of the bark or extract to sunlight and air. It is clearly necessary to know the constitution of the extracts before mangrove liquors can be improved sufficiently to allow the establishment of an industry based on mangrove tanning.

Dr. T. Dalzell has now completed his investigation under the general direction of Professor D. Burton, M.B.E., and supervision of Professor A. G. Ward, O.B.E., and Dr. H. E. Nursten.

Anthocyanogens were detected in mangrove (*Rhizophora mucronata*) extract and a study was made of their conversion into anthocyanidins. Two red substances were obtained which were separated by chromatography on "Perlon" powder. One proved to be cyanidin, and the other an artefact whose formation could be avoided by carrying out the hydrolysis of the anthocyanogens in the absence of alcohol.

Although it is not possible to state precisely how much anthocyanogen is present in the bark extract it is estimated that the content is of the order of 20 per cent.

Bristol University, Department of Organic Chemistry

Strychnos toxifera *alkaloids*

Mr. D. A. Yeowell continued his investigations under the supervision of Dr. A. R. Battersby. Three new alkaloids were isolated and the structure of one elucidated. Work is continuing on the structure of the other two alkaloids.

Manchester College of Science and Technology—Department of Chemistry

Alkaloid constituents of some Colonial and Commonwealth plants

Under the supervision of Professor Haszeldine and Dr. J. E. Davis new or partially characterized alkaloids are to be isolated and identified and these will be submitted to pharmacological testing.

Nottingham University, Department of Pharmacy

Steroidal sapogenins from Dioscorea *species*

Under the supervision of Professor Trease, Mr. G. Blunden has begun a study of the yams of British Honduras as sources of steroidal sapogenins, with special reference to *Dioscorea hondurensis*.

APPENDIX I

VISITS OVERSEAS

In January Dr. Raymond, who is head of the Section dealing with oilseeds, visited the West African Stored Products Research Unit in Nigeria, at their invitation. He took part in meetings to discuss the work on palm oil and groundnut oil which is being carried out in Nigeria and at the Tropical Products Institute, and also visited the West African Institute for Oil Palm Research.

Dr. E. M. Thain, head of the Pyrethrum Research Section, visited East Africa during January and February. In Kenya research on pyrethrum was discussed with government and industrial organizations and with growers, and visits were also made to pyrethrum growers in Tanganyika. During his visits to Zanzibar and Aden Dr. Thain was able to suggest ways in which the Tropical Products Institute could assist in these territories.

Dr. G. B. Pickering, head of the Essential Oils and Spices Section, visited Kenya, the Seychelles, Zanzibar, Tanganyika and Northern and Southern Rhodesia in March, April and May. He was able to discuss the work which his section is doing for these territories, particularly with regard to the production of essential oils in East Africa and cinnamon in the Seychelles.

Dr. L. Horton, the Assistant Director in charge of the Research Division, visited agricultural departments, and research and educational establishments in East, Central, South and West Africa during April, May and June. The organizations visited included Kawanda Research Station, Uganda ; Makerere College, Kampala, Uganda ; the Scott Laboratories, Kenya ; the Coffee Research Station, Ruiru, Kenya ; the Sisal Research Station, Kenya ; the Molo Horticultural Research Station, Kenya ; the Sisal Research Station, Tanganyika ; the Agricultural Veterinary Departments, Tanganyika ; the C.S.I.R. Laboratories, Pretoria, Union of South Africa ; the Ministry of Agriculture, Northern Region, Nigeria ; the West African Stored Products Research Unit, Kano, Nigeria ; the Federal Institute of Industrial Research, Lagos, Nigeria ; the West African Institute for Oil Palm Research, Benin, Nigeria ; University College and the Nigerian College of Arts, Science and Technology, Ibadan, Nigeria ; the West African Cocoa Research Institute, Ghana ; University College of Ghana ; the West African Rice Research Station, Sierra Leone. Dr. Horton also visited the Gambia and Senegal.

Dr. L. R. B. Shackleton, head of the Development Section, visited Algeria, Egypt, Israel, Cyprus and Malta in July and August. The main purpose of these visits was to discuss the use of solar energy in those countries, and also to make enquiries into the supply of water, methods of sewage disposal and agricultural conditions.

Mr. A. E. Chittenden and Mr. E. R. Palmer, of the Pulp and Papermaking Section, visited Scandinavia and Germany during August and September. The primary purpose of the visit was to inspect experimental pulp and papermaking machinery in connection with technical assistance which the Institute is giving to Nigeria. At the same time they studied the experimental methods used for the evaluation of raw materials for paper pulp and board production, at research institutes in Stockholm, Oslo, Hamburg, Hanover and Brunswick.

Mr. R. D. Coveney, in charge of the Hides, Skins and Tanning Section visited East Africa, Nigeria and the Gambia in September and October. Visits were arranged by Veterinary Departments to local centres of the leather industry, and

to the Federal Institute of Industrial Research in Lagos, Nigeria. Mr. Coveney also visited the Lafia canning factory at Ibadan, Nigeria, on behalf of the Fruit and Vegetables Section of this Institute.

Dr. R. H. Kirby, the Assistant Director in charge of the Economics Division, visited in October, November and December Hong Kong, North Borneo, Brunei, Sarawak, Thailand and Pakistan, where he discussed economic and agricultural problems with government and United Nations officials and scientific workers. In Japan he visited research Institutes and discussed economic problems and fibre and papermaking.

Mr. L. H. Greenwood-Barton, head of the foods section, visited America and the West Indies in October, November and December. In Canada and the United States he visited food research laboratories and government departments concerned with food and agriculture. In Jamaica, Antigua, Trinidad and British Guiana visits were made to Departments of Agriculture and Fisheries, Ministries of Trade and Industry and, in Kingston, to the Industrial Development Corporation.

INTERNATIONAL MEETINGS

Dr. W. D. Raymond, O.B.E., attended a meeting of the Oils and Fats Division of the International Union of Pure and Applied Chemistry at Bari, in September, and also a meeting of the International Standards Organization held at Budapest in the same month to discuss methods for the analysis of fats and oilseeds.

Dr. G. R. Ames, who is working in the Research Division on Sugar Esters, attended the International Congress of Surface Activity in Cologne during September. He was also able to visit Laundry Institutes at Krefeld in Germany and Delft in Holland after attending the Congress.

During his visit to Africa from April to June Dr. L. Horton attended the First Federal Science Congress, held in Salisbury University, Southern Rhodesia.

Dr. R. H. Kirby attended the F.A.O. Pulp and Paper Conference at Tokyo in October and Mr. Chittenden contributed a background paper entitled "Some Aspects of Small-Scale Industrial Pulp and Paper Production" for this Conference.

Mr. A. E. Chittenden (in collaboration with Mr. C. Swaby, Forestry Adviser, Colonial Office) presented a paper entitled "Potentialities of Tropical Forestry in the World's Timber Economy" to the 5th World Forestry Congress, Seattle, U.S.A., in August.

APPENDIX II

COUNTRIES FROM WHICH ENQUIRIES HAVE BEEN RECEIVED, 1960

Country		*Country*	
Aden	13	Nyasaland	11
Australia	12	Pakistan	7
Austria	1	Portugal	2
Belgian Congo	1	Sarawak	1
Brazil	1	Seychelles	13
British Guiana	16	Sierra Leone	9
British Honduras	5	Singapore	9
Burma	2	Solomon Is.	1
Canada	1	Somaliland	1
Ceylon	7	South Africa	15
Colombia	3	Southern Rhodesia	8
Cuba	1	Spain	2
Cyprus	7	Sudan	5
East Africa (General)	5	Switzerland	3
Kenya	57	Tonga	2
Tanganyika	47	United Kingdom	307
Uganda	15	U.S.A.	10
Ethiopia	2	West Indies (General)	14
Falkland Is.	5	Barbados	1
Fiji	20	Jamaica	33
Finland	1	Leeward Is.	
Gambia	2	Antigua	5
Germany	2	Trinidad	10
Ghana	7	Windward Is.	
India	6	Dominica	4
Iran	2	Grenada	2
Israel	3	St. Lucia	2
Malaya	12	Zanzibar	9
Malta	12		
Mauritius	14	*General*	
Mexico	6	Colonies	5
Mozambique	1	Commonwealth	1
Netherlands	1	International	11
New Zealand	2	Total No. of countries	62
Nigeria	72	Total enquiries	902
North Borneo	4		
Northern Rhodesia	30		

APPENDIX III

STAFF OF THE TROPICAL PRODUCTS INSTITUTE
31st DECEMBER 1960

Director: E. S. Hiscocks, M.Sc., F.R.I.C.
Personal Assistant: Miss D. Huddlestone.

ADVISORY DIVISION

Assistant Director: Vacant.
Personal Assistant: Vacant.
Typist: Miss K. Gahan.

Section I. Essential Oils

Principal Scientific Officer: G. B. Pickering, M.A., B.Sc., D.Phil., A.R.I.C.
Senior Experimental Officers: E. G. Brown, B.Sc., W. S. A. Matthews, A.R.I.C.
Assistants (Scientific): P. S. Beevor, A. T. Umoh.

Section II. Oils, Fats, Waxes

Principal Scientific Officer: W. D. Raymond, O.B.E., B.Sc., Ph.D., F.R.I.C.
Senior Scientific Officer: J. A. Cornelius, B.Sc., Ph.D., A.R.I.C.
Assistant Experimental Officers: J. M. Broadbent, T. W. Hammonds.
Assistant (Scientific): Miss A. G. Player.

Microbiology Section

Experimental Officer: Miss A. J. Sheridan, B.Sc., M.Inst.Biol.
Assistant (Scientific): Miss V. Cole.

Section III. Foods, Feeding stuffs

Principal Scientific Officer: L. H. Greenwood-Barton, B.Sc., F.R.I.C., F.R.S.H.
Senior Scientific Officer: D. Halliday,* B.Sc., A.R.I.C.
Experimental Officers: Miss J. Ingram, P. C. Crowther, A. Hoffman, B.Sc.
Assistant Experimental Officer: B. H. Barnes.
Assistant (Scientific): T. P. A. Mellon.
*Seconded to West African Stored Products Research Unit, Nigeria.

Section IV. Drugs, Insecticides

Principal Scientific Officer: A. J. Feuell, B.Sc., Ph.D., A.R.I.C.
Senior Scientific Officer: J. A. Dawson, B.Sc., A.R.I.C.
Experimental Officer: L. Donegan.
Assistant (Scientific): Miss I. Goodman.

Section V. Fruit, Vegetables

Chief Experimental Officer: E. H. G. Smith, M.A.
Senior Scientific Officer: G. E. Howard, B.Sc., Ph.D., A.R.I.C.
Experimental Officers: Miss J. H. Gawler, B.Sc., Mrs. D. E. Kay.

Section VI. Animal Products

Experimental Officer: R. D. Coveney, B.Sc.

Section VII. Fibres

Senior Scientific Officer: Miss V. Laws, B.Sc., M.Sc.
Experimental Officers: W. H. Hale, Dip.Timb.Tech., C. G. Jarman, B.Sc., M.Inst.Biol.
Assistant (Scientific): Miss M. Collingwood.

Section VIII. Pulp and paper-making

Senior Experimental Officer: A. E. Chittenden.
Experimental Officer: E. R. Palmer.
Assistants (Scientific): Miss H. J. Cosburn, W. G. Sparksman.

RESEARCH DIVISION

Assistant Director: L. Horton, B.Sc., Ph.D., A.R.C.S., D.I.C., A.R.I.C.
Personal Assistant: Miss T. M. Bertram.

Section A. Organic Chemistry

Senior Scientific Officer: K. Jewers, B.Sc., Ph.D.
Experimental Officer: G. G. Shone, B.Sc.
Assistant (Scientific): Miss P. J. Rose.

Section B. Sugar Esters

Scientific Officer: G. R. Ames, B.Sc., Ph.D., A.R.I.C.
Assistant Experimental Officer: Mrs. H. M. Blackmore.
Assistant (Scientific): T. A. King.

Section C. Pyrethrum

Principal Scientific Officer: E. M. Thain, B.Sc., Ph.D., A.R.I.C.
Senior Research Fellow: P. J. Godin, B.Sc., Ph.D., A.R.C.S., D.I.C.
Assistant Experimental Officer: Miss H. Inglis.
Assistant (Scientific): M. Snarey.

Section D. Plant Chemistry

Senior Scientific Officers: Mrs. B. F. Nesbitt, M.A., Ph.D., K. Sargeant, B.Sc., Ph.D.
Experimental Officer: J. C. O'Kelly, B.Sc.
Assistant (Scientific): Miss H. Brown.

Section E. Physical Chemistry

Principal Scientific Officer: H. J. Dothie, B.Sc., F.R.I.C.
Senior Scientific Officer: T. J. Coomes, B.Sc.
Experimental Officers: H. J. Warlow, A. B. Wood, B.Sc.
Assistant Experimental Officer: D. J. Crook, B.Sc.
Assistant (Scientific): K. F. Herbert.

ECONOMICS DIVISION

Assistant Director: R. H. Kirby, B.Com., Ph.D.
Personal Assistant: Miss E. M. Farrier.

Economics and Statistics Section

Principal Scientific Officer: Miss E. Orr, B.Sc. (Econ.).
Assistant Experimental Officer: P. J. R. Breslin.
Officers: A. G. Fortey, B.A., F. W. Hibbert, R. N. Horne, B.A.
Clerical Officers: Miss A. Devine, R. Pope.
Clerical Assistant: Mrs. V. Hodgson.

Bulletin Section

Experimental Officer: Miss M. Kershaw, B.Com.

ADMINISTRATION AND DEVELOPMENT DIVISION

Assistant Director: P. C. Spensley, M.A., B.Sc., D.Phil., F.R.I.C.
Personal Assistant: Miss E. E. Jacobs.
Typist: Miss J. DaCosta.

Development Section

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APPENDIX IV

PAPERS PUBLISHED IN 1960

1. AMES, G. R., Long chain derivatives of mono and oligo-saccharides. *Chemical Review*, 1960, **60**, 541–553.
2. AMES, G. R., RAYMOND, W. D., and WARD, J. B., The bleachability of Nigerian palm oil. *J. Sci. Food Agric.*, 1960, **11**, April (4), 194–202.
3. CHITTENDEN, A. E., and WATSON, A. J., Beating comparisons between Lampen mills. *Paper Technology*, 1960, **1**(6), 645–652.
4. CHITTENDEN, A. E., EDWARDS, Miss E. E. L., and PALMER, E. R., Pulping trials on *Ricinodendron rautanenii* timber from Northern Rhodesia. *Tropical Science*, 1960, **2**(1 & 2), 72–81.
5. CHITTENDEN, A. E., and PALMER, E. R., Pulping trials on three species of Pine from Mauritius. *Tropical Science*, 1960 **2**(1 & 2), 82–89.
6. CROWTHER, P. C., and SMITH, E. H. G., Dates from Eastern Aden Protectorate. *Tropical Science*, 1960, **2**(1 & 2), 90–92.
7. EDWARDS, Miss E. E. L., and HOWARD, G. E., Destructively distilled turpentine from Cyprus. *Tropical Science*, 1960, **2**(1 & 2), 97–98.
8. KAY, Mrs. D. E., and SMITH, E. H. G., The production and world trade in fresh pineapples. *Tropical Science*, 1960, **2**(1 & 2), 55–63.
9. KAY, Mrs. D. E. and SMITH, E. H. G., A review of market and world trade in bananas. *Tropical Science*, 1960, **2**(3), 154–165.
10. MATTHEWS, W. S., and PICKERING, G. B., Patchouli from the Seychelles. *Tropical Science*, 1960, **2**(1 & 2), 93–96.
11. RAYMOND, W. D., Industrial mechanization in the under-developed territories. *Journal and Proceedings of the Institution of Agricultural Engineers*, 1960, **16**(3), 70–78.
12. SMITH, E. H. G., KAY, Mrs. D. E., The utilization of citrus fruit. *J. Sci. Food Agric.*, 1960, **11**(4), 181–188.

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